



A low-angle photograph of an industrial facility. The foreground is dominated by a series of large, white, curved pipes or ducts that spiral upwards. In the middle ground, a person is silhouetted against a bright window, looking towards the machinery. The background shows a dark, industrial interior with a corrugated metal ceiling. The overall lighting is dramatic, with strong highlights from the window and deep shadows elsewhere.

07

**WORK – RESOURCE-
EFFICIENT INDUSTRIES
FOR SUSTAINABLE
GROWTH**

07

WORK – RESOURCE-EFFICIENT INDUSTRIES FOR SUSTAINABLE GROWTH



Singapore believes that growth and environmental sustainability are compatible and mutually reinforcing. Over the years, we managed to achieve economic growth together with a good quality environment. We did this by introducing policies early in the course of industrial development to safeguard environmental quality. Economic growth in turn gives us the means to further improve our living environment.

Going forward, we want to build even cleaner and more resource-efficient industries, which will help industries improve cost competitiveness, and open new economic opportunities for Singapore. We will achieve these goals in a few ways:

- Promoting energy efficiency among industries and businesses
- Enhancing water security and efficiency to support growing industrial needs
- Promoting waste minimisation and recycling in industry to conserve resources
- Controlling pollution from industries to ensure that industrial growth does not come at the expense of public health and the environment
- Promoting Clean Technology and Sustainable Urban Solutions as new growth sectors

Key Recommendations

Promoting Energy Efficiency

- 1 Facilitate energy-related benchmarking for key industrial sectors.
- 2 Establish a national Energy Efficiency Circle Programme to promote a culture of sustained energy efficiency improvement in companies.
- 3 Promote more energy-efficient technologies and systems, such as co-generation and tri-generation within power generation plants and industrial facilities, and green data centres.

Enhancing Water Security and Efficiency

- 4 Expand NEWater infrastructure and promote water efficiency to support future industry needs.

Promoting Waste Minimisation and Recycling

- 5 Set standards for recycled products to increase their uptake.
- 6 Introduce an accreditation system for companies that recycle construction and demolition waste.
- 7 Extend the Singapore Packaging Agreement beyond the food and beverage industry.

Controlling Pollution

- 8 Cap ambient SO₂ levels at an annual mean of 15µg/m³ by 2020 and maintain the same ambient SO₂ levels in 2030.

Promoting Clean Technology and Sustainable Urban Solutions

- 9 Promote Clean Technology and Sustainable Urban Solutions as new economic growth sectors, in tandem with our sustainable development efforts.
- 10 Develop a 55ha CleanTech Park at Jalan Bahar as a platform for test-bedding clean technologies.



KEPPEL MERLIMAU COGEN

Keppel Merlimau Cogen is a 500MW natural gas-fired combined cycle co-generation plant located on Jurong Island. The project provides utilities like steam, de-mineralised water, firefighting water, cooling water and pipe service corridor to industrial and utility consumers on Jurong Island. Co-generation is typically 30-40% more competitive in the production of

steam vis-à-vis conventional boilers due to its higher efficiency. By consolidating demand for utilities, third party utilities providers like Keppel Merlimau can produce utilities at lower prices through greater economies of scale. Chemical companies benefit both from lower price of utilities as well as the ability to outsource non-core functions to the Multi-Utilities Service Providers.

PROMOTING ENERGY EFFICIENCY

Today, the industry sector accounts for more than half of total national energy consumption. If we make our industries more energy efficient, we can greatly enhance Singapore's energy security and make our economy more resilient to fluctuations in energy supply. Energy efficiency will also improve the cost competitiveness of our industries, especially that of energy-intensive industries such as our refinery, petrochemical, electronics and pharmaceutical industries.

To encourage businesses to invest greater management attention and resources in energy efficiency, we have to provide companies with more information on energy efficiency,

help them build energy management expertise and support them with financing through co-funding schemes. We have already embarked on several initiatives in these areas.

Raise Awareness

The National Environment Agency (NEA) and its partners periodically organise seminars, conferences and workshops to bring together local and overseas experts and various stakeholders to share knowledge, expertise and best practices in energy efficiency. NEA has also developed a website, www.e2singapore.gov.sg, that provides information on available energy efficiency schemes and energy efficiency case studies.

Build Capability

The Energy Sustainability Unit (ESU) of the National University of Singapore (NUS) has developed a Singapore Certified Energy Manager (SCEM) programme that offers a formal training and certification system in the area of energy management. NEA provides an SCEM training grant that offsets a portion of the training fees for the curriculum. The ESU of NUS also operates an accreditation scheme for Energy Services Companies (ESCOs) to enhance the professionalism and quality of energy services offered.

Facilitate Adoption

NEA's Design for Efficiency Scheme (DfE) provides funding assistance to investors in new facilities in Singapore to integrate energy and resource efficiency improvements at the design stage. Designing an industrial facility in an energy efficient manner ex-ante is more cost-effective and can achieve greater energy savings as compared to implementing retrofitted upgrades after a facility has been built.

NEA has established an Energy Efficiency Improvement Assistance Scheme (EASe) to co-fund the cost of energy audits by up to 50%, to encourage companies to study their energy consumption and identify potential areas for improvement. NEA's Grant for Energy Efficient Technologies (GREET) scheme helps companies to offset part of the cost of implementing energy efficiency measures. Companies can also tap on the Investment Allowance (IA) Scheme if the capital expenditure results in greater energy efficiency.

In the future, we hope to further improve energy efficiency in our industries with the following new initiatives:

- **Facilitate Energy-Related Benchmarking:** In our industry consultations, many companies indicated that energy benchmarks are useful in helping them improve their energy efficiency. The government will work with leaders in various industries to conduct studies to establish appropriate energy-related benchmarks for key industrial sectors. With these benchmarks, companies will be better able to assess their relative energy performance and their energy efficiency potential.
- **Establish a National Energy Efficiency Circle Programme:** NEA will introduce an Energy Efficiency Circle Programme to promote a culture of sustained energy efficiency improvement in our companies, similar to what had been done for productivity with Quality Circles. An Energy Efficiency Circle programme is built around small groups of employees that regularly identify potential energy efficiency opportunities in their area of work and discuss what can be done to realise this potential. This programme will provide tools for companies to involve employees in energy efficiency improvements, as well as recognition for companies that have done so.
- **Promote Energy Management Practices:** The government will study the feasibility of mandating certain energy management practices for large energy users, such as the appointment of trained energy managers and the implementation of an energy management system (EMS) within companies. EMS helps companies integrate energy efficiency into their management practices. Implementing an EMS involves a company identifying key energy performance

indicators, setting baseline standards and energy efficiency goals, setting up a cross-divisional team to develop and implement an action plan to achieve the goals and setting up systems to monitor the company's energy performance. It also involves informing workers of the company's energy efficiency goals, training workers to implement energy efficiency systems and rewarding staff for achieving energy savings. Global companies that have an EMS have demonstrated that it can bring about significant benefits. For example, 3M achieved a 35% improvement in energy productivity between 2000 and 2005, and this translated to cost savings of US\$190 million. Toyota improved energy intensity by 26% in eight years, while Dow Chemical improved energy intensity by 22% between 1994 and 2005, and is targeting another 25% cut from 2005 to 2015.

- **Promote Co-generation and Tri-generation Technology:** We will achieve energy efficiency if more industries use co-generation and tri-generation technology. Co-generation is the simultaneous production of both electricity and useful heat (steam) from a fuel source. It can reduce the amount of fuel needed to generate both electricity and steam by 15-20%, as compared to generating them separately. Tri-generation plants are even more efficient as the same fuel source is also used to produce chilled water. For companies with combined demand for electricity and steam, or electricity, steam and chilled water, co-generation and tri-generation can result in significant energy savings. Currently, such technology is utilised by multi-utilities service providers (MUSP) on

Jurong Island and by companies in Tuas. The government will continue to work with the private sector to extend the MUSP models to other industrial sectors and geographical areas within Singapore.

- **Promote Energy Efficiency in Data Centres:** Data centres, server rooms and IT equipment account for a significant amount of energy use in buildings. The government will work with the Information and Communications Technology (ICT) industry to develop and promote the adoption of green data centre standards that will reduce the power consumption of IT systems. These standards will take into account the ongoing international efforts in this area as well as guidelines and best practices for data centre design, setup and operations. The public sector will also adopt green data centre practices and promote awareness of green data centre benefits among data centre operators in the public sector, develop training and certification programmes for the public and private sector data centre operators, and promote R&D in energy efficient data centres.
- **Establish Energy Efficiency Standards:** The government will continue to study global best practices in promoting energy efficiency and where appropriate, refine our local legislative and regulatory framework. For instance, we will study the experiences of countries that have legislated minimum energy efficiency standards for major energy-consuming equipment and systems, and examine if it is feasible to use legislation to further promote energy efficiency.



Localised water supply could be developed to meet non-domestic water demand in industrial clusters

ENHANCING WATER SECURITY AND EFFICIENCY

Water is a key resource that supports the growth of our industries. Today, the non-domestic sector accounts for half of Singapore's water demand. The demand for water will increase as water intensive industries such as petrochemical and wafer fabrication continue to grow. Hence, we have to continually develop alternative sources of water supply and promote water efficiency.

In the future, we will make the following additional efforts to expand water supply:

- **Expand NEWater Capacity:** PUB will steadily expand Singapore's NEWater production capacity and the distribution network. We

will complete the construction of the fifth and largest NEWater plant to date (50mgd) at Changi by 2010, and link the NEWater clusters with pipes to form an island-wide network. Industries in wafer fabrication and petrochemical require highly purified water. By supplying them with NEWater, we can better meet their needs and reduce the demand for potable water.

- **Develop Localised Water Supply:** A large portion of non-domestic demand is concentrated in industrial clusters such as Jurong Island. There is potential to develop localised sources to meet these needs, through measures such as process water recycling and desalination. In these clusters, there are also opportunities to recover heat for water production. A promising example

is membrane distillation, which taps low-grade steam or waste heat from power stations, incineration plants or industrial processes to supplement the energy requirements for desalination. PUB is now planning for a demonstration plant to validate the technical and economic feasibility of this system. Once the results are proven, PUB will work closely with the private sector to commercialise it.

NEWater and desalinated water are more resilient to changes in weather. The expansion of these unconventional sources of water will increase our water supply and help us meet any future challenges to our water supply posed by weather changes.

We will also step up our efforts to promote water efficiency:

- **Promote Awareness:** PUB will facilitate sharing of best practices and expertise in water-efficient design and management through outreach and education programmes. It will develop self-diagnostic tools to allow industry users to assess their performance relative to similar organisations and industry benchmarks, and identify opportunities for improvement.
- **Build Capabilities:** PUB will equip facility and operation managers with water audit skills through the Water Efficiency Manager Course, so that they can identify gaps and develop their own water conservation strategies.
- **Promote Industry-led Initiatives:** PUB will seek to help industries manage their water demand through financial incentives as well as recognition and awards under the 10% Challenge programme. For example, the Water Efficiency Fund will help industries

to defray part of the capital costs of water recycling systems. The Water Efficient Buildings programme encourages the use of water-efficient fittings and assists building owners in monitoring their water consumption. PUB will adopt a sector-specific approach to identify areas for improvement in water conservation, starting with hotels, schools and commercial buildings.

PROMOTING WASTE MINIMISATION AND RECYCLING

Singapore needs to reduce the amount of waste it generates as it has limited land for landfill and incineration plants. NEA will seek to promote waste minimisation and recycling through a few ways.

- **Promote Less Packaging:** An effective way of reducing waste is to reduce the amount generated during production. In June 2007, NEA signed a voluntary Singapore Packaging Agreement with NGOs, industry associations and businesses in the food and beverage sector. Signatories undertake to re-design their product packaging to reduce waste, such as by using less material, and using more recycled or recyclable materials. The agreement will be expanded in future to cover other product lines.
- **Provide Financial Support for Recycling:** NEA will launch a 3R (Reduce, Reuse, Recycle) Fund in 2009 to co-fund projects that minimise waste and promote recycling. These projects include provision of waste recycling infrastructure, re-design of processes to reduce waste, and the provision of innovative sorting or recycling equipment or systems.



Pollution control requirements are imposed on industries to manage their impact on the environment

- **Promote Use of Recycled Products:** NEA is working with industry associations such as the Waste Management and Recycling Association of Singapore (WMRAS) to set standards for recycled products to promote their use among industries. For example, NEA worked with the National Parks Board (NParks), a major generator of horticultural waste and a major consumer of compost, to set recycled content requirements for compost. WMRAS also worked with the Building and Construction Authority (BCA) and NEA to set up a new industry-led accreditation system for construction and demolition waste recycling facilities, to raise the quality and standards of recycled construction material.

CONTROLLING POLLUTION

NEA imposes pollution control requirements on all industrial developments to prevent, reduce and control pollution. Major industrial developments are required to carry out pollution control studies to assess all sources of pollution and to recommend mitigating measures that can be incorporated into the design and operation of the developments. For instance, industries have to observe emission concentration standards for air pollutants and controls on fuel quality. After industrial developments are set up, NEA requires them to carry out self-monitoring to ensure that these standards are adhered to. NEA also carries out regular checks, such as

source emission testing and fuel analyses, and takes enforcement action against violators.

Singapore will have to be more vigilant towards pollution control as our city becomes more densely built. Therefore, we will continue to review and enhance our pollution control regulations in the future.

- **Capping Sulphur Dioxide Emission:** NEA will continue to review pollution standards and requirements regularly to ensure that they are in line with international best practices while not imposing prohibitive costs on the industry. In particular, a key air pollutant of concern from industry is sulphur dioxide (SO₂) which can impair respiratory functions and aggravate existing respiratory and cardiovascular diseases. NEA will seek to achieve the goal of capping ambient SO₂ levels at an annual mean of 15µg/m³ in 2020, and maintaining it at this level in 2030. It will therefore work with major emitters, such as oil refineries, petrochemical plants and power generation companies, to use cleaner fuels and put in place more pollution control measures.
- **Managing Noise Pollution:** Singapore's dense urban landscape means that noisy activities (such as construction works) are sometimes located close to residences. The government takes a balanced approach towards controlling environmental noise – it recognises that a certain amount of noise is inevitable, but requires industry to take measures to ensure that noise levels remain acceptable. NEA develops noise pollution standards and guidelines that are benchmarked to international standards, in consultation with the industry. However, as we strive for a higher quality of life in Singapore over time, NEA may need to both review

these measures as well as consider new ones, such as tightening construction noise limits.

PROMOTING CLEAN TECHNOLOGY AND SUSTAINABLE URBAN SOLUTIONS

In the next decade, the government will invest more in developing clean technology¹ and sustainable urban solutions² as new growth areas. Apart from overcoming our own constraints, this will also allow us to contribute to sustainable development in the region and beyond.

The Economic Development Board (EDB) will nurture new economic opportunities in clean technologies and urban solutions in three ways:

- **Create a Vibrant Research Ecosystem:** EDB will create a vibrant research ecosystem in clean technology and urban solutions, comprising world-class R&D centres, equipment companies, supplier base, testing and certification services, funds and incubator projects. EDB will establish high-quality environment research centres of excellence that can train specialised manpower as well as provide technical expertise to the local industry. In addition, it will put in place new programmes to groom talent and specialist manpower. These include funding research centres of excellence to train manpower,

¹ Although there is no standard definition, clean technology is often referred to as products, services, and processes that harness renewable materials and energy sources, dramatically reduce the use of natural resources, and cut or eliminate emissions and wastes.

² Sustainable urban solutions refer to products and services that meet the needs of those living in cities, which include traffic management, waste collection, recycling, pollution control and water supply.



JALAN BAHAR CLEANTECH PARK

The Jurong Town Corporation (JTC) and Economic Development Board (EDB) are developing the Jalan Bahar CleanTech Park for companies undertaking clean technology activities such as R&D, test-bedding, prototyping and light manufacturing. The Park will showcase sustainable building and infrastructure features and provide a plug-and-play environment to facilitate test-

bedding of Urban Solutions that are practical and scalable. This CleanTech Park will focus on achieving low carbon emissions, and integrate existing surrounding ecological features with the built-up area. Located next to Nanyang Technological University (NTU), the 55ha CleanTech Park will be developed over 20 years with the first development ready in 2011.



SOLAR ENERGY RESEARCH INSTITUTE OF SINGAPORE (SERIS)

In the last few years, Singapore has already attracted an array of private Cleantech R&D centres such as GE Water, Siemens Water, Bosch (solar) and Vestas (wind). Cleantech R&D centres were also launched in our institutes of higher learning. These include the Solar Energy Research Institute of Singapore (SERIS) in the National University of Singapore (NUS), NUS Environmental Research Institute (NERI) and Nanyang Environment and Water Research Institute (NEWRI).

SERIS is Singapore's national laboratory for innovative solar energy research and was set up in April 2007 as part of the National University of Singapore (NUS). It has a budget

of \$130 million over five years and is led by CEO Professor Joachim Luther, formerly the Director of the Fraunhofer Institute for Solar Energy Systems (ISE). The institute seeks to collaborate with industry on solutions-focused R&D in the areas of crystalline and thin-film silicon solar technology, novel photovoltaic devices as well as solar and energy-efficient buildings. SERIS also provides testing and certification services for solar photovoltaic modules under New Energy Technology Pte Ltd, a tripartite partnership between SERIS, VDE Institute and Fraunhofer ISE. Currently staffed by a team of 30 personnel, the institute is expected to grow to 100 researchers by 2011.

more scholarship programmes and a visiting professor programme. It will also provide funds on a competitive basis to encourage local research institutes to undertake breakthrough R&D activities in clean technology and other urban solutions.

- **Facilitate Test-Bedding:** As a small, compact and densely populated urban centre with a strong regulatory framework, Singapore is an ideal living laboratory for companies to test-bed and adapt solutions for use worldwide. Siemens is already setting up its Global Centre of Competence for City Management here. This centre will be a test-bed and launch pad for innovative IT solutions in city management. Many other local and foreign companies have also used Singapore as a launch pad to initiate R&D projects and test out their new ideas and solutions before exporting them to emerging cities in China, India, Southeast-Asia and the Middle East.

To further consolidate Singapore as a living laboratory for companies, the government will make available public facilities such as water treatment plants, incineration plants

and public transportation systems as development platforms for the private sector to test-bed technologies. This will catalyse public-private sector collaborations to develop new solutions for Singapore as well as allow private sector companies, both local and overseas, to test-bed new technologies that can be subsequently exported worldwide.

- **Expand and Deepen the Industry Cluster in Clean Technologies:** EDB will actively seek to attract leading global companies in clean technologies to base their headquarters, manufacturing and business development operations, as well as R&D facilities in Singapore. These investments will further facilitate the transfer of know-how and promote collaboration between global companies and our local research institutes and companies. At the same time, the government will step up efforts to help our local companies better internationalise their business and operations, such as organising related industry conferences and trade exhibitions to profile the companies' products.

CONCLUSION

Economic growth and environmental sustainability go hand-in-hand. By making concerted efforts to boost the resource efficiency of our industries and develop clean technology as a new economic growth area, we can achieve environmental sustainability while supporting future economic growth.